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Data-Driven Granular Fluid Dynamics Model

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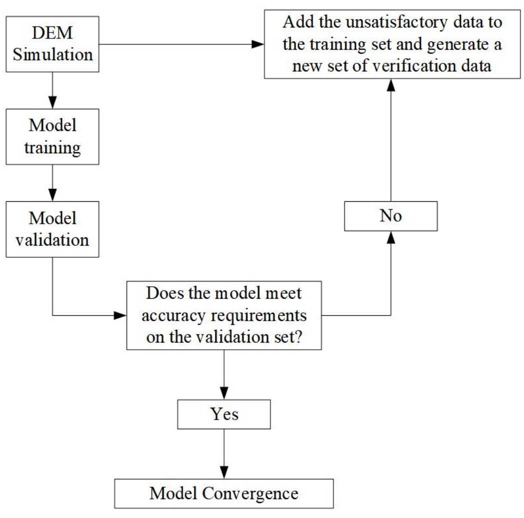
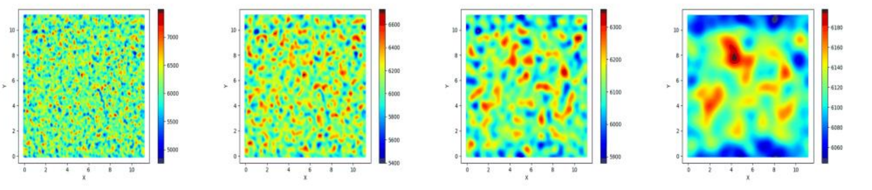
Introduction

This paper aims to develop a data-driven granular fluid dynamics model to enhance understanding and predictive ability of granular flow across multiple scales. Specific objectives include integrating traditional dynamical models with machine learning algorithms to improve the accuracy and efficiency of models in handling complex fluid systems, developing models capable of simultaneously addressing micro and macro-scale phenomena to better capture the full picture of granular flow, and ensuring the model's adaptability and practicality in applications, particularly in terms of energy conservation and improving production efficiency.

Methods



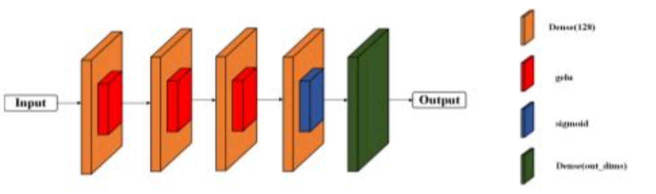
Model Training Process Diagram



Various Scale Data Diagram

$$\frac{\partial U}{\partial t} + \nabla \cdot F = S$$

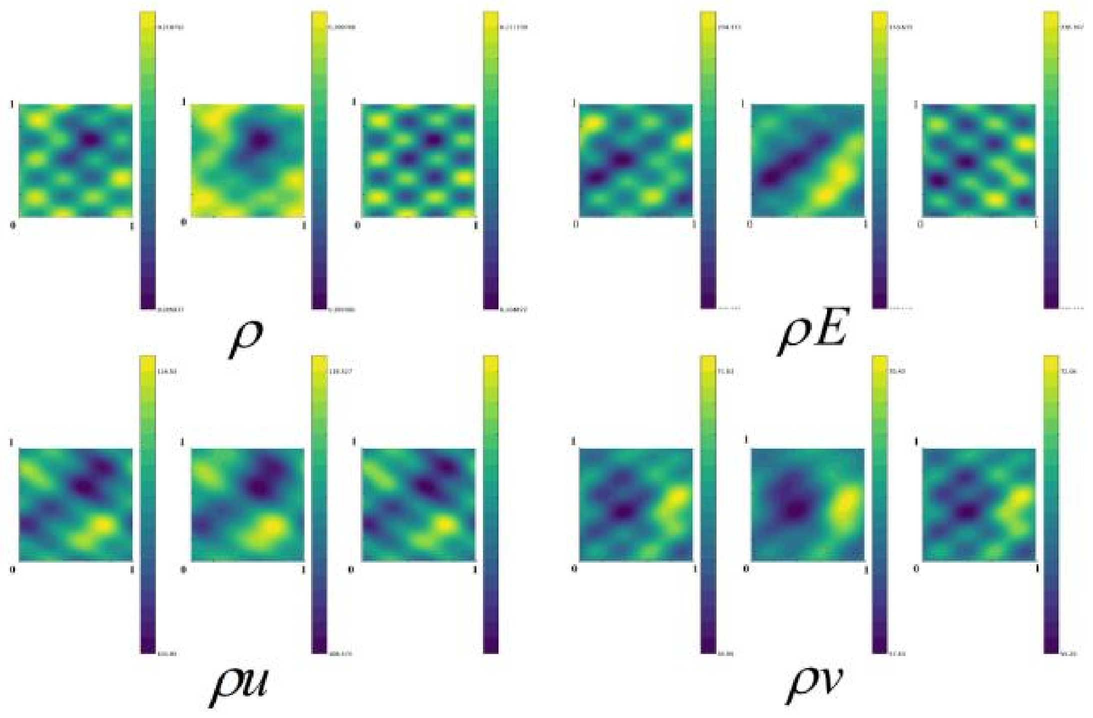
$$U = \begin{pmatrix} \rho \\ \rho u \\ \rho v \\ \rho E \end{pmatrix}$$



$$\frac{\partial U}{\partial t} + \nabla \cdot F_{NN} = S_{NN}$$

ANN Model

Results



Real values, results from Navier-Stokes equations, and predictions from Artificial Neural Networks, comparison analysis.

Conclusions

This study has developed a data-driven particulate fluid dynamics model that integrates Artificial Neural Networks (ANN) to learn and predict the dynamic behavior of particulate flows. By exploring the integration of traditional dynamical models with modern machine learning algorithms, this paper successfully demonstrates the effectiveness and efficiency of multiscale modeling in handling complex particulate systems. Particularly, utilizing microscale data generated from Discrete Element Method (DEM), this model not only enhances computational efficiency but also ensures adaptability and accuracy under various operational conditions.

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